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(57) Abstract

A reinforced concrete tile is provided with substantially increased tensile strength and lightness in weight by a lightweight substrate layer of reinforced resinous material which has been applied while wet to the lower surface of layer of concrete so as to integrally bond itself to the layer of concrete. The substrate layer may comprise a resinous mixture reinforced with fibres or with a mesh of fibreglass or other appropriate composition. In a first method of making reinforced concrete tiles, a concrete tile which has been formed has the bottom surface thereof treated so as to roughen the surface and remove any loose debris therefrom. A layer of reinforced resinous material is then applied to the bottom surface of the concrete tile. In a second method of making a reinforced concrete tile, wet concrete is extruded onto a pallet having an upper surface, which may be formed by a liner of appropriate configuration to impart a wood shingle appearance, and which defines the top surface of a tile to be formed. After shaping the wet concrete tile on the pallet, a layer of reinforced resinous material is applied to the surface of the wet concrete tile opposite the pallet, so as to form a reinforced substrate layer on the base of the concrete tile being formed, before curing and removing the tile. The layer of reinforced resinous material may be applied by application of layers of resinous slurry before and after application of a layer of mesh, or by pressing the mesh onto a layer of slurry using a roller. The layer of mesh can be offset to form the base of a moulded sidelock portion of the tile and to help secure the tile to an underlying roof structure. In accordance with still further methods, reinforced tiles are formed by disposing a layer of mesh between concrete layers of different thickness and by placing a layer of mesh on the upstanding pegs of a pallet and forming the concrete tile thereover.

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REINFORCED CONCRETE TILES AND METHODS OF MAKING THE SAME

The present invention relates to reinforced concrete tiles, particularly concrete roof tiles, and to methods for making reinforced concrete tiles.

Concrete tiles have found widespread application in the construction industry. In particular, concrete roof tiles have been found to provide an excellent roof covering for various structures, in terms of longevity, durability, inflammability, and other desirable factors. Concrete roof tiles can assume a number of different forms. Typically, such tiles are relatively thin and of generally uniform thickness, and have a profile which may vary from flat to undulating in configuration.

Concrete roof tiles are typically made by transporting wet concrete from either a continuous mixer or a batch mixer to a succession of moving pallets, arranged end-to-end on a conveyor. The pallets define the general shape of the tiles to be formed. As each pallet passes within a making head assembly, wet concrete is dispensed and extruded onto the pallet, with the help of a rotating roller which meters the concrete onto the pallet and compresses the wet concrete to a desired thickness. The pallet is then passed beneath a slipper which engages the wet concrete and has a profile selected to provide the concrete with a desired cross-sectional configuration. A knife or cutting assembly cuts the continuous ribbon of concrete formed on the end-to-end succession of pallets to define the individual tiles and to shape the edges thereof. The pallets with the wet concrete extruded, compressed, shaped and cut thereon are then separated and advanced to a racker, where the pallets are loaded onto racks for transport to a curing facility. The curing facility typically comprises an oven in which the tiles are heated at a desired temperature and for a desired period of time to cure the concrete. Following that, each concrete tile is removed from its supporting pallet, to thereby provide the completed concrete tiles.

One disadvantage of concrete roof tiles and other concrete tiles, when compared with certain other types of tiles of different construction, relates to the nature of concrete. Concrete tends to be relatively strong in compression but weak in tension. Consequently, while concrete tiles are typically capable of withstanding substantial compressive forces, such tiles can only endure a limited amount of tensile force before cracking or breaking. In the case of concrete roof tiles, such tiles are typically mounted on supporting battens on the surface of the roof understructure or, in one alternative arrangement, the tiles are nailed direct to the roof understructure in overlapping relationship up a roof. Consequently, each tile spans a gap or space between an opposite pair of supporting battens or between the understructure and a headlap portion of a tile below on a roof. When stepped on by a person walking on the roof, the weight of an ordinary person is often enough to crack or break the concrete tile because of the relatively low resistance thereof to tensile forces.

A number of different solutions have been proposed for reinforcing concrete structural members. Examples of such are provided by US Patents 2292444 of Haydon et al, 2560781 of Schaaf, 2740162 of Knight, 2805448 of Rubenstein, 3870546 of Gelsomino, 4088808 of Cornwell and 4132043 of Juba.

Of the patents noted above, the US 2805448 patent of Rubenstein is of particular interest because of the approach taken therein to provide a high tensile strength structural member. A formed concrete structural member is sawn off to provide a porous surface which is free of cracks, following which the concrete member is pressed into a mould having a resin-saturated fibreglass mat therein. The mould assembly is then heated in a platen press. The result is said to be a concrete structural member having a surface layer thereon providing the member with high tensile strength.

However, the US 2805448 patent of Rubenstein relates to thick concrete blocks and not to roof tiles or similar tiles of thin configuration. Moreover, the method of making concrete blocks described in the Rubenstein patent does not readily lend itself to the high production techniques required for concrete roof tiles and similar concrete tiles.

US Patent 4752520 of Franklin provides examples of reinforced concrete tiles such as concrete roof tiles, and methods of making such reinforced tiles. In the Franklin patent, wet concrete is extruded and then cured in situ on a rigid substrate which has previously been formed. This is done so that the pallets used in the formation of the tiles are not needed during the curing process. The substrate provided at the bottom of the tile is said to provide the composite tile with lighter weight then a tile of all-concrete construction, as well as greater strength.

However, tiles made in accordance with the process of Patent US 4752520 of Franklin are nevertheless of limited strength, particularly because of the manner in which such tiles are made. During formation of the rigid substrate prior to addition of the wet concrete thereto, the substrate is provided with a network of apertures. The wet concrete which is subsequently dispensed onto the formed rigid substrate is pressed against the substrate so as to push small amounts of the wet concrete into the apertures therein. As the concrete hardens and is cured, plugs are formed thereon which act to secure the substrate to the lower surface thereof. Such a technique for applying a substrate backing to a concrete tile has been found lacking in terms of the bond strength between the substrate and the concrete. It is suspected that this is because the material of the substrate does not infiltrate the porosity of the adjacent concrete so as to provide a strong, integral bond substantially throughout the entire interface between the substrate and the concrete. As a result, such tiles have been found to be lacking in the necessary structural strength, particularly tensile strength.

It would, therefore, be desirable to provide a relatively thin concrete tile of substantial tensile strength as well as improved lightness in weight. Furthermore, it would be desirable to provide various methods of making such a tile.

Reinforced concrete tiles in accordance with the invention may include a substrate layer applied to a lower surface of a layer of concrete while the substrate layer is still wet. This has been found to provide a superior bond between the substrate layer and the concrete layer throughout substantially the entire interface between.

In the case of a concrete roof tile, a substrate layer of considerable thinness applied in this fashion to the lower surface of the concrete layer has been found to provide the tile with surprisingly high tensile strength. The layer of concrete is of generally uniform thickness and has a first broad surface defining a top surface of the reinforced concrete tile and an opposite second surface. The substrate layer is integrally bonded to the second surface of the concrete layer, and preferably comprises a reinforced resin which has been applied to the second surface of the concrete layer while wet. This has been found to integrally bond the reinforced resin to the layer of concrete in superior fashion. The reinforced resin may comprise a mixture of organic resin and reinforcing fibres. The reinforced resin may also comprise a resinous slurry containing a reinforcing mesh such as a layer of fibreglass mesh. For certain applications, the concrete tile is preferably of relatively thin, generally planar configuration, and may be designed for use as a roof tile.

In a first method of making a reinforced concrete tile according to the invention, a concrete tile is first made so as to have a bottom surface. After the concrete tile is made, the bottom surface thereof is treated to roughen such surface and to remove any loose debris. Following that, a layer of reinforced resinous material is applied to the bottom surface of the

concrete tile. The concrete tile is formed in conventional fashion by extruding wet concrete onto a pallet, shaping the wet concrete, curing the wet concrete, and removing the cured concrete from the pallet to provide the concrete tile. Treatment of the bottom surface of the tile thus formed may be carried out by sandblasting the bottom surface. The reinforced resinous material may comprise a mixture of resin and reinforcing fibres, and may be applied by spraying onto the bottom surface of the concrete tile. The spraying may be carried out using a spray gun or a rotating brush disposed adjacent to the bottom surface of the concrete tile, or another suitable means such as curtain coating.

A continuous process for carrying out the first method in accordance with the invention employs a conveyor together with a sandblasting station located at the conveyor, and a layering station located at the conveyor on a downstream side of the sandblasting station. The formed concrete tiles are placed on the conveyor for transport to the sandblasting station where the bottom surface of each is sandblasted. The tiles are then transported to a layering station where a layer of reinforced resinous material is applied to the bottom surface of each concrete tile. The layering station may employ apparatus for spraying the layer of reinforced resinous material onto the bottom surface of the concrete tile.

In a second method of making a reinforced concrete tile in accordance with the invention, a conveyor pallet or other form is provided having an upper surface defining the shape of a top surface of a reinforced concrete tile to be formed. A quantity of wet concrete is extruded onto the upper surface of the form to form a wet concrete tile having a bottom surface opposite the upper surface of the form. A reinforcing substrate layer is then applied to the bottom surface of the wet concrete to form a reinforced wet concrete tile. The wet concrete tile is then cured, following which it is removed from the form to provide the completed reinforced concrete tile.

A continuous process for carrying out the second method in accordance with the invention places a plurality of pallets on a moving conveyor. Each pallet, which comprises one of the forms, has an upper surface defining the shape of a top surface of a reinforced concrete tile to be formed. Wet concrete is extruded onto the upper surface of each pallet and is shaped to form wet concrete tiles. The reinforcing substrate layer is applied to each wet concrete tile, following which the wet concrete tiles are cured and then removed from the pallets. The reinforced resinous material may be applied to the bottom surfaces of the wet concrete tiles, using a layering station placed in the path of the pallets.

In accordance with the invention, the pallets on which the concrete tiles are formed and which are made of aluminium or other appropriate material are provided with liners mounted over the broad surface areas thereof. The liners are provided with grooves and are otherwise configured to provide the concrete roof tiles with a desired upper surface configuration such as a wood shingle appearance. Shaping the liner to form a central ridge therealong provides the upper surface of the concrete roof tiles with a central groove, giving the appearance of split shingles.

As previously noted, the reinforcing substrate layer applied to each concrete tile may comprise a resinous slurry having a reinforcing mesh disposed therein. In accordance with one method of applying the resinous slurry with reinforcing mesh, the concrete tile is first formed on the pallet, following which a first layer of slurry is applied to the bottom surface of the concrete tile. The reinforcing mesh is then placed on the first layer of slurry, and a second layer of slurry is applied over the reinforcing mesh, to integrate the mesh into the merging layers of slurry. Following curing of the concrete tile, the tile is removed from the pallet.

In accordance with an alternate method of applying the resinous slurry and reinforcing mesh, the concrete tile is first formed

In accordance with an alternate method of applying the resinous slurry and reinforcing mesh, the concrete tile is first formed on the pallet, following which a layer of slurry is applied to the bottom surface of the concrete tile. The reinforcing mesh is then placed on the layer of slurry, and is pressed into the layer of slurry using a roller. This integrated the mesh into the substrate layer formed with the resinous slurry, so that a further coat of the slurry is not needed.

The resinous slurry may comprise any appropriate resin or resin composition. One preferred composition comprises a mixture of fibreglass, Portland cement, modifiers and silica sand.

The reinforcing mesh may comprise a single piece or a plurality of pieces of reinforcing mesh material. The plural pieces may be of different size or thickness, or may be overlapping or not, as desired. For most applications, however, adequate reinforcement is provided by a single piece of mesh of generally planar configuration and of appropriate composition such as alkali resistant fibreglass.

The reinforcing mesh may overlie the concrete tile so as to be generally coextensive therewith and with the substrate layer formed thereon. However, in accordance with an alternative embodiment of the invention, the mesh can be offset so as to extend outwardly along the side of the main portion of the concrete tile. Such offset portion of the mesh can be used to form a sidelock portion of the tile, such as by vacuum forming a plastic tray of appropriate configuration on the mesh. The resulting sidelock portion integrates with the overlapping sidelock portion of an adjacent concrete tile in the usual sealing fashion. Because the moulded sidelock portion utilises the extending portion of the thin mesh as the base thereof, thereby providing a relatively thin sidelock, the thickness of the concrete tile can be substantially reduced from that usually required to form the tile with concrete sidelocks at both side edges thereof.

In accordance with a further alternative embodiment according to the invention, the reinforcing mesh can also be offset so as to extend outwardly from the upper edge of the concrete tile. Such extending portion of the mesh provides a convenient way of mounting the concrete tiles on a supporting roof structure, using nails, staples or the like, and thereby eliminating the need for nail holes or the like within the concrete tiles. For such applications, the extending portion of the mesh is preferably plastic coated to facilitate the securement thereof to the underlying roof support structure using such fasteners.

In accordance with a further alternative method of making concrete tiles in accordance with the invention, a relatively thin layer of wet concrete is formed on the pallet. Following formation of this first layer of wet concrete, reinforcing mesh is placed thereon. Then, a second layer of wet concrete is formed over the mesh and the first layer of wet concrete. The first and second layers of wet concrete are then cured, before removal from the pallet. The first layer of concrete, which is provided with a greatly reduced amount of colouring oxides, may be considerably thinner than the second layer. In this way, the resulting tile is provided with colouring oxides through only that portion thereof where such colouration is needed. Such process lends itself to the addition of the reinforcing mesh as the two different concrete layers of somewhat different composition are successively formed on the pallet.

In accordance with a still further alternative method of making a reinforced concrete tile in accordance with the invention, the pallet is provided with a plurality of upstanding pegs. Reinforcing mesh is placed over the pegs and is shaped as necessary so as to reside above the upper surface of the pallet. Wet concrete is then dispensed onto the pallet and over the mesh to form a wet concrete tile having the mesh embedded therein. The pallet is then passed beneath a conventional roller and slipper assembly for compacting and shaping the wet concrete tile before curing the wet concrete tile and removing it from the pallet.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a roof assembly comprised of a plurality of reinforced concrete roof tiles in accordance with the invention;
Figure 2 is an end view of the roof assembly of Figure 1, showing the manner in which the individual reinforced concrete roof tiles may be subjected to tensile stress;
Figure 3 is a perspective view of a reinforced concrete roof tile of the roof assembly of Figure 1, showing the reinforcing substrate layer thereof;
Figure 4 is a perspective view of an endless conveyor line used in a continuous process of making reinforced concrete tiles in accordance with a first method of the invention;
Figure 5 is a perspective view of a portion of the endless conveyor line of Figure 4 showing the manner in which the bottom surface of each concrete tile is treated to roughen the surface and remove loose debris;
Figure 6 is a perspective view of a portion of the endless conveyor line of Figure 4 showing one technique for applying a layer of reinforced resinous material to the bottom surface of each concrete tile following the treatment of the bottom surface as shown in Figure 5;
Figure 7 is a perspective view of an endless conveyor line used in a continuous process for making reinforced concrete tiles in accordance with a second method of the invention;
Figure 8 is a perspective view of a pallet used in making reinforced concrete tiles in accordance with the invention;
Figure 9 is a sectional view of the pallet of Figure 8 taken along the line IX-IX thereof;
Figure 10 is a perspective view of the pallet of Figure 8 showing the manner in which a reinforced concrete tile is formed thereon;

Figure 11 is a perspective view of a reinforced concrete tile made using the pallet of Figure 8;

Figure 12 is an exploded perspective view of a reinforced concrete tile, illustrating a third method of making such a tile in accordance with the invention;

Figure 13 is a sectional view of a portion of the reinforced concrete tile of Figure 12;

Figure 14 is a plan view of a concrete tile with the reinforcing mesh being offset relative thereto, in accordance with a further embodiment of the invention;

Figure 15 is a front edge view of a reinforced concrete tile formed in accordance with the configuration shown in Figure 14;

Figure 16 is a perspective view of the tile shown in Figure 15;

Figure 17 is an exploded perspective view of a reinforced concrete tile, illustrating a fifth method of making such a tile in accordance with the invention;

Figure 18 is a perspective view of a pallet having upstanding pegs thereon for supporting a reinforcing mesh and used in accordance with a sixth method of making reinforced concrete tiles according to the invention.

Figure 1 shows a roof assembly 10 which includes a plurality of reinforced concrete roof tiles 12 in accordance with the invention. The roof assembly 10 includes a roof understructure 14 of plywood or other appropriate construction on which are mounted a plurality of battens 16. The roof tiles 12 are mounted on the spaced-apart battens 16 on the roof understructure 14.

As shown in Figure 1, the roof tiles 12 are arranged in overlapping rows, which include a first row 18 having a lower edge overlapping a second row 20. The second row 20 is only partially shown in Figure 1. Each of the roof tiles 12 within the first row 18 has a lower end 22 thereof which overlaps an upper end 24 of a corresponding one of the roof tiles 12 within the second row 20. The lower ends 22 of the roof tiles 12

within the first row 18 and the upper ends 24 of the roof tiles 12 within the second row 20 are supported by a first one 26 of the battens 16. Each of the roof tiles 12 within the first row 18 has an opposite upper end 28 mounted on a second one 30 of the battens 16. Each of the upper ends 28 is provided with apertures through which nails 32 are driven to mount the roof tiles 12 of the first row 18 on the roof. The upper ends 24 of the roof tiles 12 within the second row 20 are similarly nailed to the first one 26 of the battens 16 to mount the roof tiles 12 of the second row 20. Such nails are not shown in Figure 1, inasmuch as they are covered by the lower ends 22 of the roof tiles 12 within the first row 18.

Figure 2 is an end view of the roof assembly 10 of Figure 1, showing the manner in which each of the roof tiles 12 spans a space above the roof understructure 14 between the opposite ends thereof. As shown in Figure 2, one of the roof tiles 12 of the first row 18 has the upper end 28 thereof nailed to the second one 30 of the battens 16, as previously described. The opposite lower end 22 of the roof tile 12 rests upon the upper end 24 of the adjacent roof tile 12 within the second row 20, which upper end 24 is nailed to the first one 26 of the battens 16, as previously described.

It periodically becomes necessary for persons to walk on a roof such as the roof assembly 10 shown in Figure 1. This may be required in order to reach a portion of the roof to conduct repairs thereon, for example. It may also be necessary in order to conduct maintenance, such as painting windows or other portions of the building containing the roof assembly 10. When a person walks on the roof tiles 12, a downward force is exerted on the tiles. If the person steps on the unsupported intermediate portion of a roof tile 12, as represented by a downwardly directed arrow 34 shown in Figure 2, then the underside of the roof tile 12 is subjected to tensile stress, while the top of the roof tile 12 is subjected to compressive stress. Concrete is relatively strong in compression, so that the compressive stress

at the upper portion of the roof tile 12 is not a problem. However, the tensile stress at the underside of the roof tile 12 can be a substantial problem, inasmuch as concrete is relatively weak in tension.

To compensate for these problems, the roof tiles 12 in accordance with the invention are reinforced with a substrate layer 36 which is integrally bonded to a bottom surface 38 of a layer of concrete 40, to form the reinforced concrete roof tile 12. This is best shown in Figure 3, in which the substrate layer 36 is shown integrally bonded to the bottom surface 38 of the layer of concrete 40. As described in detail hereafter, the substrate layer 36, which comprises a reinforced resin, is applied while wet to the bottom surface 38 of the layer of concrete 40 so as to integrally bond the substrate layer 36 to the layer of concrete 40 throughout substantially the entire interface therebetween. As shown in Figure 2, the substrate layer 36 at the underside of the roof tile 12 serves to substantially reinforce the roof tile 12 against tensile stresses. Typically, building codes require a concrete roof tile to have a tensile strength of at least 300 lbs. By adding the substrate layer 36 to the roof tiles 12 in accordance with the invention, the tensile strength of such tiles has been found to be as high as 2000 lbs. or even more.

As shown in Figure 3, the roof tile 12 has opposite side edges 42 and 44 of ribbed configuration to enable the roof tile 12 to overlap with adjacent tiles within a row of such tiles. The side edge 42 overlaps the side edge of an adjacent tile on one side of the roof tile 12, while the side edge 44 extends underneath an overlapping side edge of an adjacent tile on the opposite side of the roof tile 12.

The roof tile 12 can be made according to a first method of the invention and this is detailed as follows. Figure 4 shows an endless conveyor line 52 which includes a continuously moving

conveyor 54 arranged into an endless loop. The conveyor line 54 continuously moves in the direction shown by an arrow 56.

A plurality of pallets 58 are placed end-to-end on the continuously moving conveyor line 54 upstream of a making head assembly 60. As the end-to-end pallets 58 pass through the making head assembly 60, a continuous ribbon of wet concrete is extruded onto the pallets 58 in conventional fashion. The end-to-end pallets 58 carry the continuous ribbon of wet concrete from the making head assembly 60 to a knife assembly 62 located downstream therefrom. The knife assembly 62 cuts the ribbon of concrete adjacent the front and rear edges of each pallet 58, in conventional fashion, so as to form the opposite edges of a succession of concrete tiles. From the knife assembly 62, the pallets 58 containing the wet concrete tiles thereon are advanced to a racker 64 of conventional design. The racker 64 loads the pallets 58 with the wet concrete tiles thereon onto racks 66. When each rack 66 is fully loaded, a forklift carries the loaded rack 66 to a curing facility (not shown) where the concrete is cured. The process is conventional, and typically takes about 6 hours.

Following curing of the wet concrete tiles on the pallets 58, a forklift is used to return the rack 66 containing the cured tiles and the supporting pallets 58 to the racker 64. In the process, a depalleter (not shown) is employed to remove the cured concrete tiles from the supporting pallets 58, following which the concrete tiles are loaded onto the conveyor line 54 just downstream of the racker 64. The conveyor line 54 carries the concrete tiles to a sandblasting station 68 where the bottom surface of each concrete tile is treated to roughen the surface and remove any loose debris therefrom. A detailed example of the sandblasting station 68 is shown in Figure 5.

In the example of Figure 5, the sandblasting station 68 includes a sandblasting head 70 extending across the width of the conveyor line 54. Each of the concrete tiles is placed face down on the

conveyor line 54 so that the bottom surface 38 thereof is exposed. As each concrete tile passes beneath the sandblasting head 70, sand is directed under pressure onto the bottom surface 38 to roughen such surface and to remove any loose debris therefrom. Following sandblasting by the head 70, the concrete tile is passed beneath a blower assembly 72, where jets of air are directed onto the bottom surface 38 to remove any residue of sand, dust and debris.

Referring again to Figure 4, the concrete tiles with the bottom surfaces thereof treated within the sandblasting station 68 are advanced by the conveyor line 54 to a layering station 74, for application of a layer of reinforcing resinous material to the bottom surface. A detailed example of the layering station 74 is shown in Figure 6.

Referring to Figure 6, the concrete tiles on the conveyor line 54 are passed beneath a spraying assembly 76 for application of the layer of reinforcing resinous material thereto. The spraying assembly 76 may comprise a conventional spray gun. Alternatively, the resinous material can be sprayed onto the bottom surface of each concrete tile by applying the reinforced resinous material to a rotating bush disposed adjacent the bottom surface of the concrete tile. US Patent 4743471 of Shills, which issued 10 May 1988, and which has one inventor who is common with one of the inventors of the present application, provides an example of an applicator having a rotating brush which can be used for this purpose.

Following application of the layer of reinforcing resinous material, the layer of material is allowed to dry and harden. In the case of the reinforced concrete roof tiles 12 of Figures 1-3, this forms the substrate layer 36 on the bottom surface 38 of the layer of concrete 40.

The reinforced resinous material applied to form the substrate layer 36 may comprise a mixture of organic resin and reinforcing

fibres. The reinforcing fibres may, for example, comprise polyester fibres or fibreglass fibres. The resin may comprise an epoxy resin or a polyester resin, although other resinous compositions may be used.

It has been found that by applying the reinforcing resinous material to the concrete tile while wet, and then allowing the resinous material to dry, the resinous material penetrates the porous bottom surface 38 of the concrete tile so as to form an integral bond of extreme strength between the substrate layer 36 and the layer of concrete 40 throughout substantially the entire interface therebetween.

Figure 7 provides an example of a continuous process for making reinforced concrete tiles in accordance with a second method of the invention. The arrangement of Figure 7 includes an endless conveyor line 86 comprised of a conveyor line 88 which moves in the direction shown by an arrow 90. A plurality of pallets 92 are placed end-to-end on the conveyor line 88 for movement into a making head assembly 94. The making head assembly 94 functions essentially in the same manner as the making head assembly 60 of Figure 4 to extrude and thereby form a continuous ribbon of wet concrete on the end-to-end succession of pallets 92. One difference, however, is that in the arrangement of Figure 7, the upper surface of each pallet 92 defines the upper or top surface of the concrete tile being formed thereon. In other words, the concrete tiles are formed "upside-down" on the pallets-92.

From the making head assembly 94, the continuous ribbon of wet concrete is conveyed to a knife assembly 96, which cuts the ribbon of concrete adjacent the opposite edges of each pallet 92 to form individual wet concrete tiles, in the same manner as does the knife assembly 62 in the arrangement of Figure 4. Unlike the arrangement of Figure 4, however, the cut ribbon of wet concrete in the arrangement of Figure 7 is carried by the conveyor line 88 directly into a layering station 98. Like the

layering station 74 shown in Figures 4 and 6, the layering station 98 of Figure 7 applies a layer of reinforcing resinous material to the bottom surface of each wet concrete tile being formed, such as by spraying. Thus, the wet layer of reinforcing resinous material is applied while wet to the bottom surface of each concrete tile while still wet.

Following application of the reinforcing resinous material, the pallets 92 which contain the wet concrete tiles are conveyed to a racker 100 which functions in much the same manner as the racker 64 of Figure 4 to load the individual pallets 92 onto racks 102 for transport to a curing facility. Following curing of the wet concrete tiles, a depalleter (not shown) is employed to separate the concrete tiles from the pallets 92 so as to form the completed reinforced concrete tiles.

As previously described, continuous conveyor processes for making the reinforced concrete roof tiles 12 in accordance with the invention may utilise a succession of pallets spaced along the conveyor. The arrangement of Figure 4 utilises the pallets 58, while the arrangement of Figure 7 utilises the pallets 92. The second method of the invention involves each tile being formed in upside-down fashion on one of the pallets 92 with the substrate layer than being applied to the exposed surface of the upside-down tile.

Figure 8 shows a pallet 110 in accordance with the invention. Because the pallet 110 is used to form a reinforced concrete roof tile thereon in upside-down fashion thereon, it may be used in the arrangement of Figure 7. The pallet 110, which is made of appropriate material such as aluminium, has a ridged sidelock-forming portion 112 thereof extending along one side of the pallet 110 between upper and lower portions 114 and 116. The upper portion 114 of the pallet 110 provides concrete roof tiles formed on the pallet 110 with a ribbed upper portion, as described hereafter in connection with Figure 11.

The pallet 110 has a broad surface area 118 thereof between the upper and lower portions 114 and 116, which is covered by a liner 120. Unlike most of the pallet 110, which is made of aluminium, the liner 120 is easily moulded to provide an exposed upper surface 122 thereof with a desired surface configuration for shaping the upper surface of concrete roof tiles formed on the pallet 110. In the present example, the upper surface 122 of the liner 120 is provided with a series of relatively small, generally parallel ridges 124 extending along the length thereof between the upper and lower portions 114 and 116 of the pallet 110. A single major ridge 126 of relatively large size extends along a central portion of the liner 120 so as to essentially divide the upper surface 122 thereof into opposite halves.

The manner in which the liner 120 is mounted on the broad surface area 118 of the pallet 110 is illustrated in Figure 9 as well as in Figure 8. As shown in Figure 9, the broad surface area 118 defines a recess in the pallet 110 in which the liner 120 is received. The liner 120 is secured within the recess of the broad surface area 118 such as by using an appropriate adhesive or screws.

The manner in which a reinforced concrete tile is formed on the pallet 110 in upside-down fashion is shown in Figure 10. Using a method such as that disclosed hereinbefore as the second method of the invention, wet concrete is extruded onto the pallet 110 and is shaped and cut to form a wet concrete roof tile 130. The sidelock-forming portion 112 of the pallet 110 forms a first sidelock 132 of the concrete roof tile 130. An opposite second sidelock 134 is formed in the concrete roof tile 130 as part of the shaping process in which the pallet 110 is passed beneath a conventional roller and slipper assembly. An upper surface 136 of the concrete roof tile 130, which forms the eventual bottom of the concrete roof tile 130, is covered with a thin substrate layer 138, in the manner of the invention. Application of the substrate layer 138 can be accomplished by applying a layer of reinforcing resinous material to the bottom surface of a wet

concrete tile, or by using one of the various techniques described hereafter.

Following application of the substrate layer 138 to the wet concrete roof tile 130, the concrete is cured, and the resulting reinforced concrete roof tile 130 is then removed from the pallet 110 as hereinbefore described.

Upon removal and inversion of the reinforced concrete roof tile 130 from the pallet 110, the finished tile is as shown in Figure 11. The tile 130 has the opposite sidelocks 132 and 134 for overlapping engagement with the mating sidelocks of adjacent roof tiles which are located on the opposite sides thereof when assembling a roof. The tile 130 also has a ribbed upper portion 140 formed by the upper portion 114 of the pallet 110. The large ridge 126 in the upper surface 122 of the liner 120 forms a large central groove 142 in an upper surface 144 of the concrete roof tile 130. The series of small ridges 124 in the upper surface 122 of the liner 120 form a series of small grooves 146 extending along the length of the upper surface 144 of the concrete roof tile 130.

The small grooves 146 in the upper surface 144 of the roof tile 130 give the roof tile a wood shingle appearance. At the same time, the large central groove 142 gives the roof tile 130 the appearance of being comprised of split shingles. It will be understood, however, that the liner 120 of the pallet 110 can be shaped so as to provide the reinforced concrete roof tiles made thereon with any desired shape and surface texture. A major advantage of using the liner 120 as a separate element to be mounted within the pallet 110 is the ease with which the liner can be shaped, such as by moulding, to form different tile shapes and surface textures. In addition, the pallets 110 can be made of like configuration, with liners 120 of different configurations being mounted on the pallet as desired.

As previously described in connection with the first and second methods of the invention, the substrate layer 36 formed on the bottom surface 38 of the reinforced concrete roof tile 12 shown in Figures 2 and 3 can comprise a reinforced resinous mixture such as a mixture of resin and fibres. As described in detail hereafter, the substrate layer can also be formed from a resinous mixture or slurry in which a mesh is used as the principal reinforcing ingredient instead of fibres. Indeed, the addition of one or more layers of mesh, such as fibreglass mesh, to the substrate layer has been found to provide the concrete tiles with very high tensile strength.

One arrangement for assembling a concrete tile so as to provide the tile with a mesh-reinforced substrate layer is shown in Figure 12. Such a tile 152 can be made according to a third method of the present invention. In Figure 12 a pallet 150, such as the pallet 110 of Figure 8, has a concrete tile 152 formed thereon. The concrete tile 152 is formed in upside-down fashion, so that the bottom surface 154 thereof is formed opposite the pallet 150. The successive steps of the third method of the invention to make a tile 152 which is illustrated by Figure 12 are as follows. A first step involves the formation of the concrete tile 152 on the pallet 150. In a second step, a first layer of slurry 160 is applied to the bottom surface 154 of the concrete tile 152, In a third step, reinforcing mesh 164 is placed on the first layer of slurry 160. In a fourth step, a second layer of slurry 168 is applied over the reinforcing mesh 164.

The slurry used in forming the first and second layers 160 and 168 may be of like composition, and is preferably a resinous mixture. One preferred mixture for use as the slurry layers 160 and 168 is comprised of chopped glass fibres, Portland cement, modifiers and silica sand. The modifiers may be polymers, or latex based compositions.

The layers of slurry 160 and 168 can be applied to the bottom surface 154 of the concrete tile 152 by any appropriate technique, such as by spraying. A rotating brush of the type previously referred to is well suited for spraying on the layers of slurry. The first layer of slurry 160 may be applied with a thickness of 1.5 mm with the slurry being a polymer modified cementitious type such as the mixture previously described. The reinforcing mesh 164, in the form of a generally planar sheet of reinforcing mesh material of fibreglass or other appropriate composition, is mechanically placed over the first layer of slurry 160. The second layer of slurry 168 is then sprayed over the reinforcing mesh 164, also to a thickness of approximately 1.5 mm. The first layer of slurry 160, which adheres to the bottom surface 154 of the concrete tile 152, interfaces with the second layer of slurry 168 at the reinforcing mesh 164. The layers of slurry 160 and 168 run together sufficiently to form a single, integral substrate layer 170 with the reinforcing mesh 164 disposed therein.

Figure 13 is a cross-sectional view of a portion of the concrete tile 152 showing the substrate layer 170 as formed on the bottom surface 154 thereof. As shown in Figure 13, the first and second layers of slurry 160 and 168 form the single, integral substrate layer 170 containing the reinforcing mesh 164 therein.

A similar tile to tile 152 produced by the third method of the invention described above can be made by a fourth method of the invention. This fourth method is similar to the third method and involves a first step in which a concrete tile is formed on a pallet and a second step in which a layer of slurry is applied to the bottom surface of the concrete tile. This is followed by a third step in which reinforcing mesh is placed on the layer of slurry, in the same manner as described above for the third method of the invention, and a fourth step in which the reinforcing mesh applied in the third step is pressed into the layer of slurry applied in the second step. This is preferably accomplished using a roller, although other pressing techniques

can be used. The roller is rolled over the reinforcing mesh with sufficient force to press the reinforcing mesh into the layer of slurry applied in the second step. This results in the reinforcing mesh being embedded in the layer of slurry, so that a reinforcing substrate layer similar to the layer 170 of Figures 12 and 13 is formed.

In the reinforced concrete tile of Figure 12, the reinforcing mesh 164, which is approximately the same size as the concrete tile 152, the first layer of slurry 160 and the second layer of 168, is positioned so as to be generally coextensive with each of these members. However, the reinforcing mesh can be offset or otherwise positioned or configured so that portions thereof extend beyond the edges of the concrete roof tile. Such a configuration, which is shown in Figures 14-16, provides certain advantages as described hereafter.

Figure 14 shows a concrete roof tile 190 in which a layer of reinforcing mesh 192, being applied to a bottom surface 194 of the roof tile 190 as part of a reinforcing substrate layer, is offset relative to the roof tile 190. The reinforcing mesh 192 is offset so that a portion 196 thereof extends beyond an upper edge 198 of the roof tile 190. The reinforcing mesh 192 has a further portion 200 which extends outwardly from a side edge 202 of the roof tile 190. Although not shown in Figure 14, the reinforcing mesh 192 is incorporated into a substrate layer formed on the bottom surface 194 of the roof tile 190 using an appropriate technique such as the third and fourth methods described above.

While the reinforcing mesh 192 is shown offset relative to the roof tile 190 in Figure 14, the mesh 192 could be configured so as to be coextensive with the roof tile 190. The important consideration is that the mesh has portions thereof, such as the portions 196 and 200, which extend beyond the upper edge 198 and the side edge 202 respectively of the roof tile 190. As described hereafter, the extending portion 196 is used to help

secure the roof tile 190 to an underlying roof support structure, while the extending portion 200 is used to form a thin sidelock along the side edge 202 of the roof tile 190.

The roof tile 190 shown in Figure 14 has a front edge 204 opposite the upper edge 198. Figure 15 is a view of the front edge 204 of the roof tile 190, with the roof tile 190 placed right-side-up so that the reinforcing mesh 192 is disposed beneath and forms a portion of a substrate layer 206 at the bottom surface 194 of the roof tile 190. The roof tile 190 is formed with a sidelock 208 extending along one side of the main portion of the roof tile 190, in conventional fashion. At the opposite side edge 202 of the roof tile 190, an opposite sidelock 210 is formed in conjunction with the extending portion 200 of the reinforcing mesh 192. The sidelock 210 is formed such as by vacuum-forming a plastic tray, having the appropriate grooved configuration, over the portion 200 of the mesh 192.

Because the sidelock 210 is considerably thinner than a sidelock formed of concrete, such as the sidelock 132 shown in Figure 11, the roof tile 190 can be made with a thickness considerably less than that which would otherwise be required. The resulting reduction in tile thickness is represented by a dotted line 212 in Figure 15. The dotted line 212 represents the outline of the tile of conventional thickness and where the sidelock 210 is made of concrete.

In spite of the greatly reduced thickness of the sidelock 210, formed using the extending portion 200 of the reinforcing mesh 192, such sidelock 210 is fully capable of integrating with the overlapping sidelock of an adjacent concrete tile so as to provide the conventional type of sealing relationship required.

Figure 16 is a perspective view of the concrete roof tile 190 showing the thin sidelock 210 at the side edge 202, formed in conjunction with the extending portion 200 of the reinforcing mesh 192. Figure 16 also shows the extending portion 196 of the

reinforcing mesh 192 at the upper edge 198 of the roof tile 190. With the roof tile 190 mounted on a roof support structure, such as the roof understructure 14 shown in Figure 1, the portion 196 facilitates mounting of the roof tile 190 thereon without the need for nail holes within the tile 190. The portion 196 of the reinforcing mesh 192 is preferably reinforced, such as by plastic dipping, to better enable the portion 196 to be attached to the underlying roof structure using fasteners such as nails, staples and the like.

Although the reinforcing mesh, such as the mesh 164 shown in Figure 12 and the mesh 200 shown in Figure 14 is shown and described as being a single, generally planar layer of the mesh, it should be understood that other mesh configurations can be used in accordance with the invention. For example, pieces of mesh of different size and/or thickness can be used. The various pieces of mesh can be overlapped or adjacent to each other, as appropriate. It is only important that the reinforcing mesh be capable of integration with the substrate layer as such layer is formed, in order to provide proper reinforcement for the concrete tile.

The second, third and fourth methods of the invention are described in terms of the tile being formed of wet concrete dispensed onto and then shaped on pallet, with the reinforcing substrate layer then being applied to the concrete while still wet. However, it should be understood that the substrate layer can be applied after the concrete has dried, if desired. Also, the concrete tile can be formed using the first method of the invention in which the tile is formed and cured before the reinforcing substrate layer is applied to the bottom thereof.

Figure 17 illustrates a fifth method of making a reinforced concrete tile according to the invention, which involves a first step in which a first layer 222 of wet concrete is formed on a pallet. This first layer 222 of wet concrete is relatively thin, and may be formed of concrete having a greatly reduced

concentration of colouring oxides therein. Because such colouring oxides are expensive, the use thereof is limited in the case of the relatively thin first layer 222. The remainder of a reinforced concrete tile 226 being formed in conjunction with the first layer 222 is comprised of a second layer of wet concrete 228 having a thickness substantially greater than the thickness of the first layer 222. The thicker second layer 228 has a normal concentration of colouring oxides therein.

Following formation of the first layer of wet concrete 222 on the pallet 224, a reinforcing mesh 230 is placed upon the first layer 222, in a second step. In a third step of this fifth method of the invention, the second layer 228 of wet concrete is formed over the first layer 222 and the reinforcing mesh 230. In this way, the tile 226 is formed by the two layers 222 and 228 with the reinforcing mesh 230 being sandwiched therein to provide reinforcement for the tile 226. The reinforcing mesh 230 is carried out as one additional step in a process which otherwise involves formation of the first layer 222 on the pallet 224, followed by formation of the second layer 228 thereon. A separate substrate layer need not be formed on the bottom surface of the concrete tile. In a fourth step, the first and second layers 222 and 228 are cured, and the formed concrete roof tile 226 is removed from the pallet 224.

A sixth method of making a reinforced concrete tile, in accordance with the invention is illustrated in conjunction with the apparatus of Figure 18, with the successive steps of such method being described below. Referring to Figure 18, a pallet 240, used in the formation of a concrete tile, is provided with a plurality of upstanding pegs 242 which extend upwardly from an upper surface 244 of the pallet 240. In the sixth method of the invention, reinforcing mesh is placed over the upstanding pegs of the pallet, and is shaped as necessary. This is illustrated in Figure 18 in which a reinforcing mesh 250 is placed on the upstanding pegs 242 of the pallet 240. The reinforcing mesh 250 is shown as being generally planar in configuration, but can be

bent over the pegs 242 and otherwise configured in non-planar fashion to achieve desired reinforcing effects. Next, wet concrete is dispensed onto the pallet 240 and over the reinforcing mesh 250 to form a wet concrete tile with the mesh 250 embedded therein. For clarity of illustration, the wet concrete tile is illustrated only by the dotted line 254, in Figure 18, which shows the outline of the wet concrete tile relative to the reinforcing mesh 250 and the upper surface 244 of the pallet 240.

With the wet concrete dispensed onto the pallet 240 and over the mesh 250, the pallet 240 is passed beneath a conventional roller and slipper assembly to compact and shape the wet concrete tile, and this is followed by the wet concrete tile being cured and then removed from the pallet 240. The reinforcing mesh 250 which is embedded within the formed tile provides reinforcement thereof, without the addition of a separate substrate layer to the bottom surface of the tile.

While various forms and modifications have been suggested, it will be appreciated that the invention is not limited thereto but encompasses all expedients and variations falling within the scope of the appended claims.

It will be appreciated that the tiles according to the invention can be mounted on supporting battens on the surface of the roof understructure or, alternatively, then can be nailed direct to the roof understructure in overlapping relationship up a roof.

Also, it will be appreciated that the liner which provides the upper surface of the tiles with the desired appearance may be provided by a moulded insert. The liner and insert may be made from any suitable material e.g. plastics, sheet metal and aluminium.

Finally, it will be appreciated that any means may be provided to press the reinforcing mesh into the layer of resinous slurry;

for example, suitable means may comprise a simple press or vibration apparatus.

CLAIMS

1. A method of making a reinforced concrete tile, comprising the steps of:
making a concrete tile having a bottom surface;
treating the bottom surface of the concrete tile to roughen the surface and remove any loose debris therefrom; and,
applying a layer of reinforced resinous material to the bottom surface of the concrete tile following treating of the bottom surface.

2. A method in accordance with claim 1, wherein the step of making a concrete tile comprises the steps of extruding wet concrete onto a pallet, shaping the wet concrete, curing the concrete, and removing the cured concrete from the pallet to provide the concrete tile.

3. A method in accordance with claim 1, wherein the step of treating the bottom surface of the concrete tile comprises sandblasting the bottom surface.

4. A method in accordance with claim 1, wherein the reinforced resinous material comprises a mixture of organic resin and reinforcing fibres.

5. A method in accordance with claim 1, wherein the step of applying a layer of reinforced resinous material comprises spraying reinforced resinous material onto the bottom surface to form a layer of desired thickness thereon.

6. A method in accordance with claim 5, wherein spraying of the reinforced resinous material is carried out using a spray gun.

7. A method in accordance with claim 5, wherein spraying of the reinforced resinous material is carried out by applying the reinforced resinous material to a rotating brush

disposed adjacent to the bottom surface of the concrete tile.

8. A method in accordance with claim 1, wherein the steps of treating the bottom surface and applying a layer of reinforced resinous material together comprise the steps of providing a conveyor, locating a sandblasting station at the conveyor, locating a layering station at the conveyor on a downstream side of the sandblasting station, placing the concrete tile on the conveyor for transport to the sandblasting station, sandblasting the bottom surface of the concrete tile at the sandblasting station, transporting the concrete tile from the sandblasting station to the layering station, and applying a layer of reinforced resinous material to the bottom surface of the concrete tile at the layering station.

9. A method in accordance with claim 8, wherein the layering station includes apparatus for spraying a layer of reinforced resinous material onto the bottom surface of the concrete tile.

10. A method in accordance with claim 8, wherein the layering station includes apparatus for curtain coating a layer of reinforced resinous material onto the bottom surface of the concrete tile.

11. A method of making a reinforced concrete tile, comprising the steps of:

providing a form having an upper surface defining the shape of a top surface of a reinforced concrete tile to be formed;

applying a quantity of wet concrete to the upper surface of the form to form a wet concrete tile having a bottom surface opposite the upper surface of the form;

applying a reinforcing substrate layer to the bottom surface of the wet concrete tile to form a reinforced wet concrete tile;
curing the reinforced wet concrete tile; and,
removing the reinforced concrete tile from the form.

12. A method in accordance with claim 11, wherein the step of applying a reinforcing substrate layer comprises applying a layer of reinforced resinous material to the bottom surface of the wet concrete tile.

13. A method in accordance with claim 12, wherein the layer of reinforced resinous material is applied to the bottom surface of the wet concrete tile by spraying.

14. A method in accordance with claim 11, wherein the step of providing a form comprises providing a pallet on a moving conveyor, the pallet having an upper surface defining the shape of a top surface of a reinforced concrete tile to be formed, and the step of applying a quantity of wet concrete comprises extruding wet concrete onto the upper surface of the pallet and shaping the wet concrete to form the wet concrete tile.

15. A method in accordance with claim 14, herein the step of applying a reinforcing substrate layer comprises locating a layering station at the moving conveyor, advancing the pallet with the wet concrete tile thereon to the layering station and applying a layer of reinforced resinous material to the bottom surface of the wet concrete tile.

16. A reinforced concrete tile comprising a layer of concrete of generally uniform thickness having a first broad surface defining a top surface of the reinforced concrete tile and an opposite second surface, and a substrate layer joined to the second surface of the layer of concrete, the substrate layer comprising a reinforced resin which has been applied

passing the pallet beneath a roller and slipper assembly to compact and shape the wet concrete tile;
curing the wet concrete tile; and,
removing the cured concrete tile from the pallet.

Fig.1

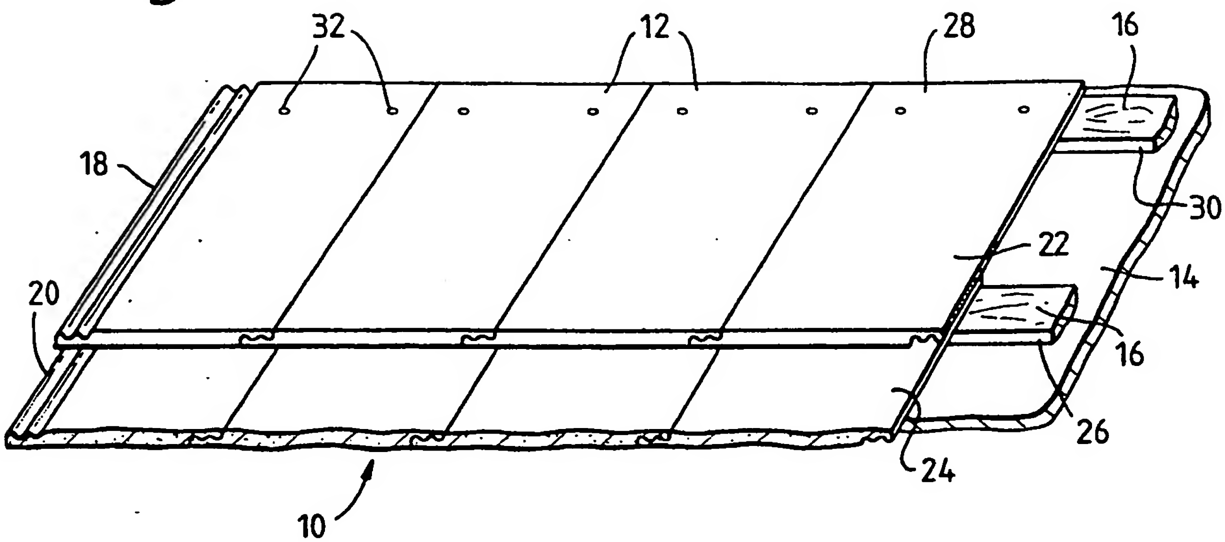


Fig.2

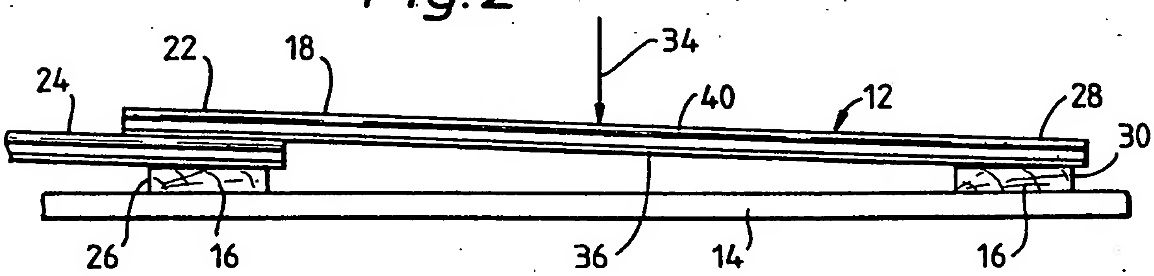


Fig.3

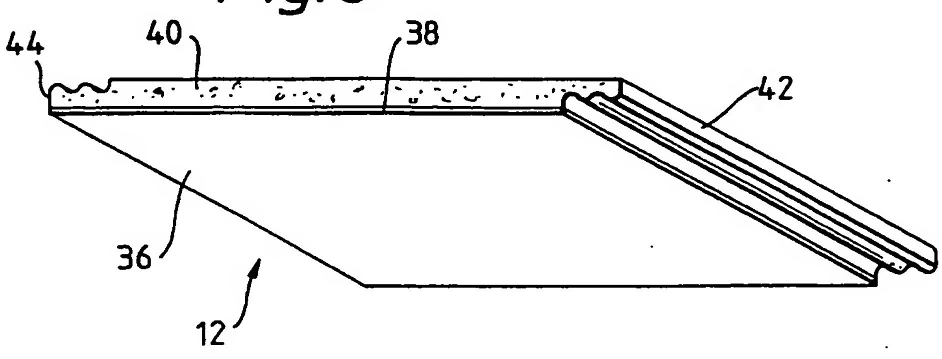


Fig. 4

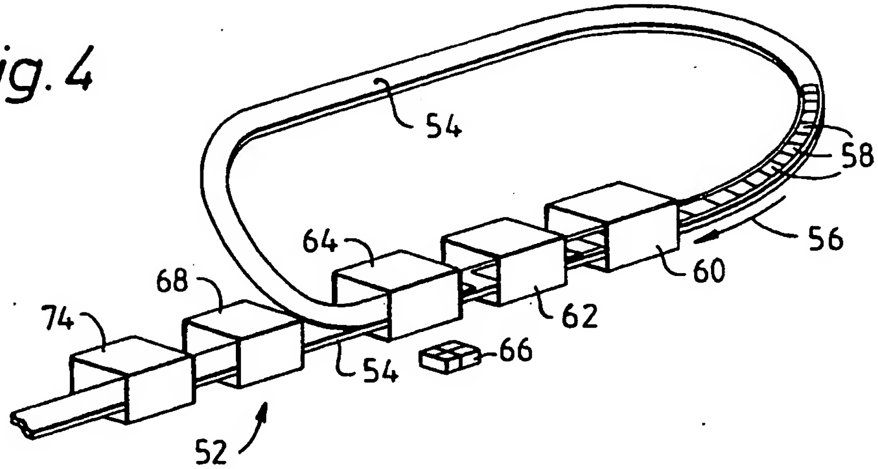


Fig.5

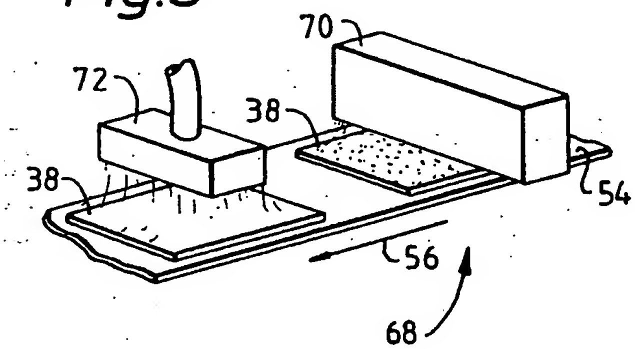


Fig. 6

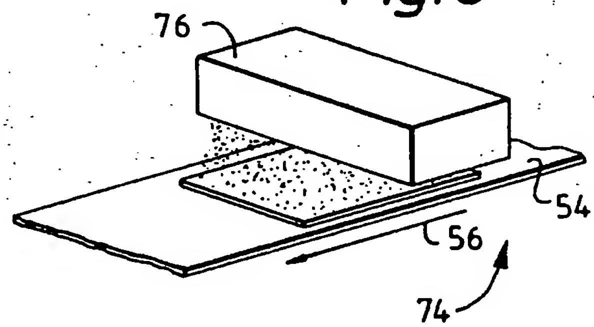


Fig. 7

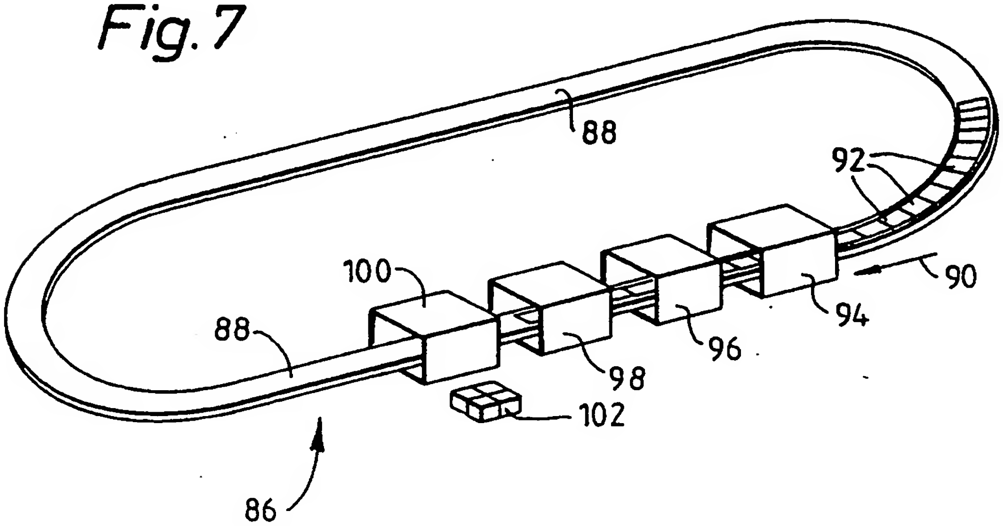
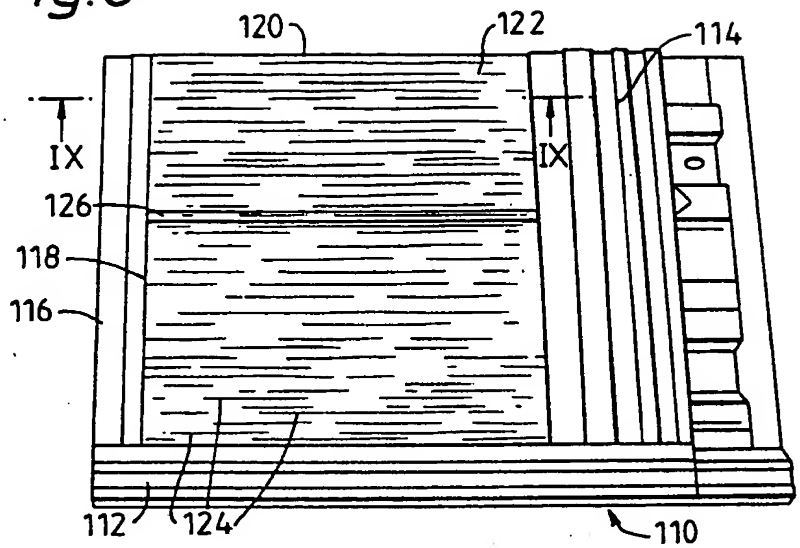


Fig.8



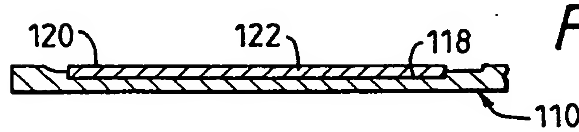


Fig.9

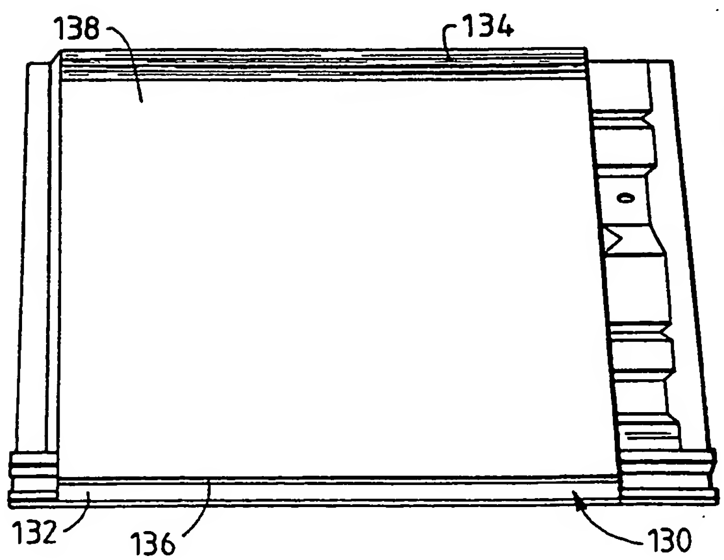


Fig.10

Fig.11

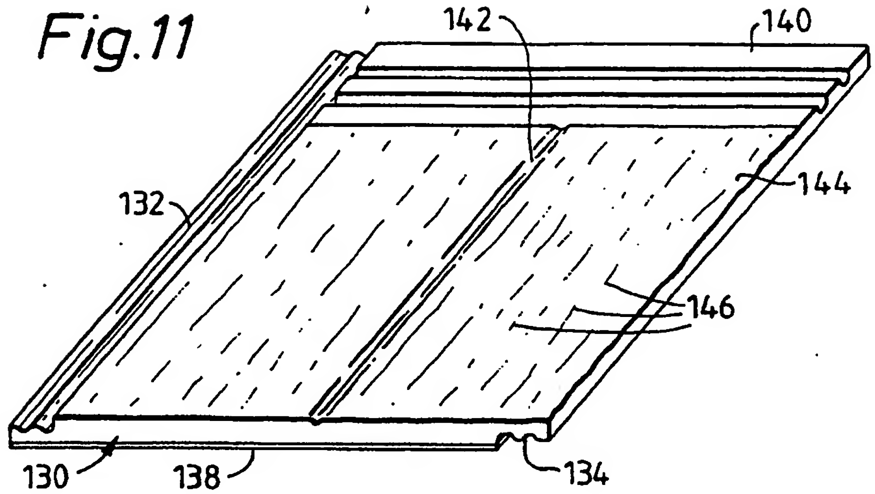


Fig.12

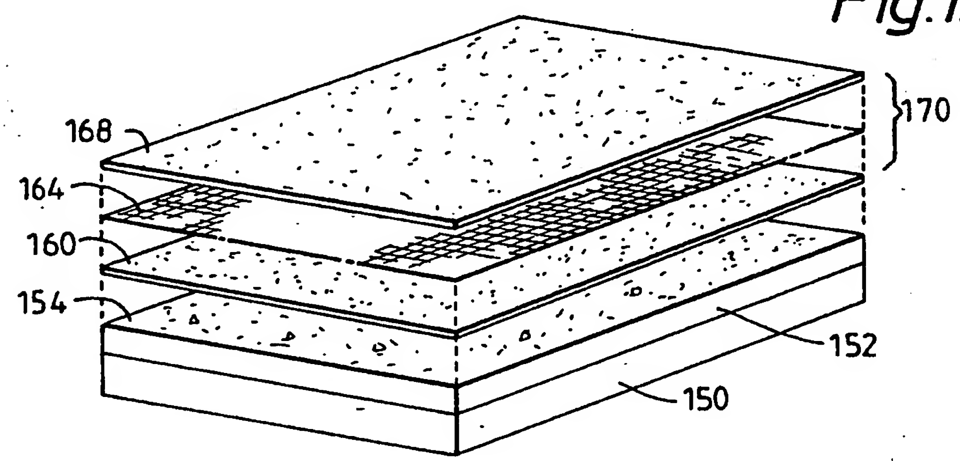


Fig.13

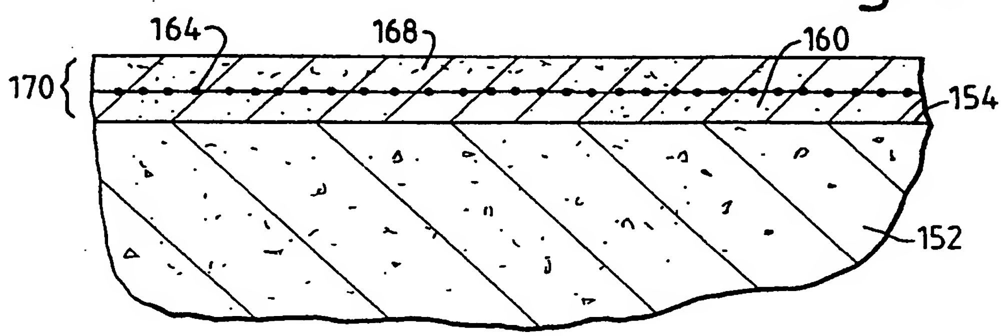


Fig. 14

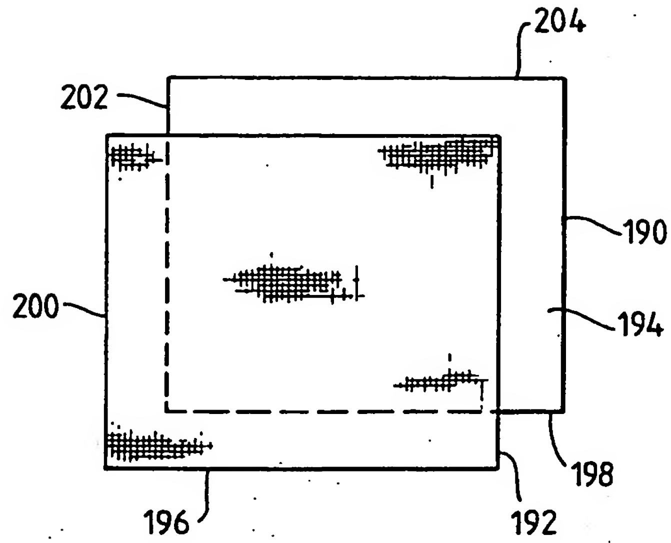
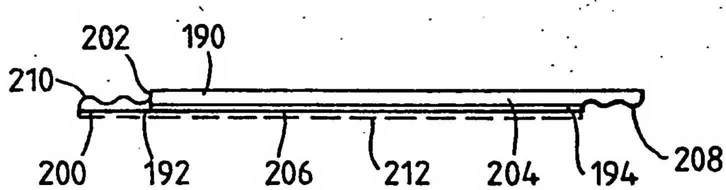


Fig. 15



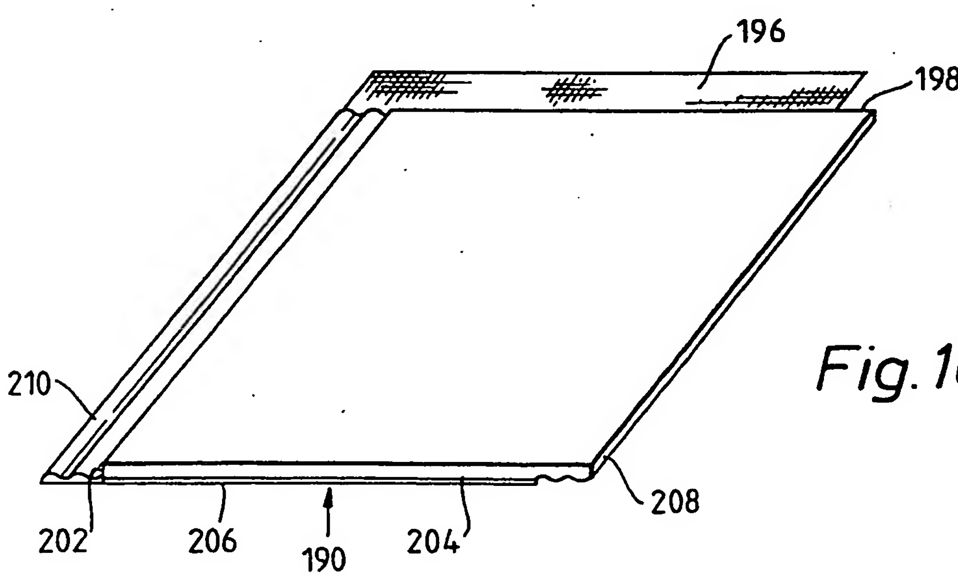


Fig. 16

Fig. 17

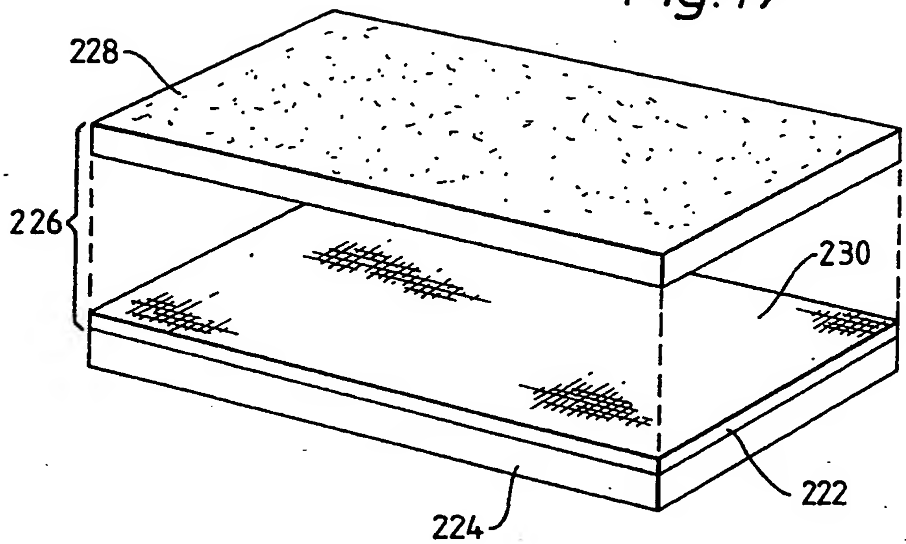


Fig. 18